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Huron County

Southern Ontario

by Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey

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Contents

Abstract 2
Introduction 3
Part I — Inventory Methods 4
Field and Office Methods 4
Resource Tonnage Calculation Techniques 4
Sand and Gravel Resources 4
Bedrock Resources 4
Units and Definitions 5
Part II — Data Presentation and Interpretation 6
Map 1 Distribution of Sand and Gravel Deposits 6
Deposit Symbol 6
Texture Symbol 6
Map 2 Selected Sand and Gravel Resource Areas 6
Site Specific Criteria 7
Deposit Size 7
Aggregate Quality 7
Location and Setting 8
Regional Considerations 8
Map 3 Bedrock Resources 8
Selection Criteria 8
Selected Resource Area 9
Part III — Assessment of Aggregate Resources in Hullett Township 10
Location and Population 10
Physiography and Surficial Geology 10
Extractive Activity 11
Selected Sand and Gravel Resource Areas 11
Selected Sand and Gravel Resource Areas 1 and 5 12
Selected Sand and Gravel Resource Area 2 12
Selected Sand and Gravel Resource Area 3 13
Selected Sand and Gravel Resource Area 4 13
Selected Sand and Gravel Resource Areas 6 and 7 13
Sand and Gravel Resource Areas of Secondary Significance 14
Bedrock Geology 15
Summary 16
References 35
Appendix A — Suggested Additional Reading 36
Appendix B — Glossary 37
Appendix C — Geology of Sand and Gravel Deposits 39
Appendix D — Geology of Bedrock Deposits 41
Appendix E — Aggregate Quality Test Specifications 44

TABLES

1. Total Sand and Gravel Resources, Hullett Township 17
2. Sand and Gravel Pits, Hullett Township 18
3. Selected Sand and Gravel Resource Areas, Hullett Township 21
4. Total Identified Bedrock Resources, Hullett Township 22
5. Quarries, Hullett Township 23
6. Selected Bedrock Resource Areas, Hullett Township 24
7. Summary of Test Hole Data, Hullett Township 25
8. Summary of Geophysics Data, Hullett Township 27
9. Aggregate Quality Test Data, Hullett Township 28

FIGURES

1. Key Map Showing the Location of Hullett Township 2
2a. Aggregate Grading Curves, Hullett Township 29
2b. Aggregate Grading Curves, Hullett Township 30
3a. Aggregate Grading Curves, Hullett Township 31
3b. Aggregate Grading Curves, Hullett Township 32
4a. Aggregate Grading Curves, Hullett Township 33
4b. Aggregate Grading Curves, Hullett Township 34

5. Bedrock Geology of Southern Ontario 41

MAPS (back pocket)

1. Distribution of Sand and Gravel Deposits, Hullett Township, Scale 1:50 000.
2. Selected Sand and Gravel Resource Areas, Hullett Township, Scale 1:50 000.
3. Bedrock Resources, Hullett Township, Scale 1:50 000.

Aggregate Resources Inventory of Hullett Township Huron County

by Staff[1] of the Engineering and Terrain Geology Section

1. Project Supervisors: Dale W. Scott and I. Szoke; field work and report by D. Tennant; compilation and drafting by Staff of the Aggregate Assessment Office. The Mineral Resources Staff of Wingham District and Southwestern Region of the Ministry of Natural Resources assisted in the collection of data, field checking and review of this report.

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Abstract

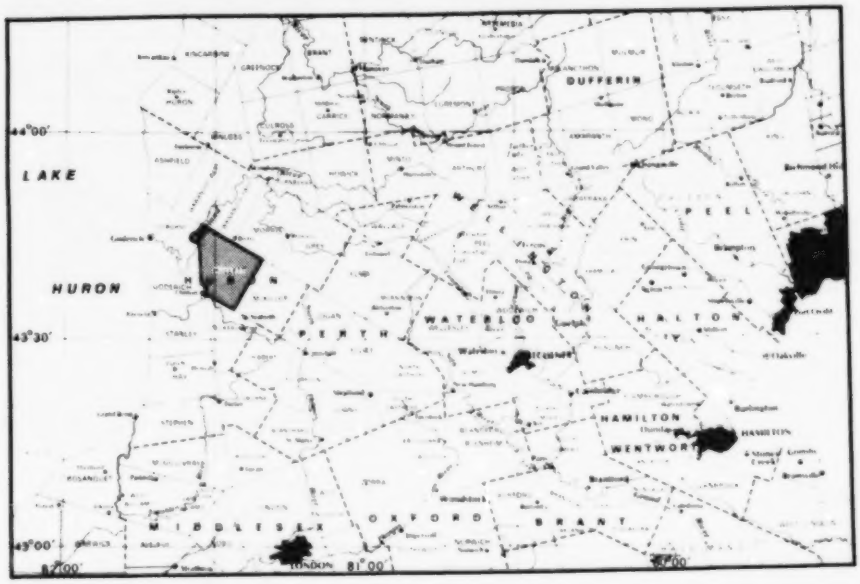


Figure 1. *Key map Showing Location of Hullett Township, Scale 1:1 800 000.*

This report includes both an inventory and analysis of sand and gravel as well as bedrock resources in Hullett Township, Huron County. The report is part of the Aggregate Resources Inventory Program for townships and municipalities designated under the Pits and Quarries Control Act.

Generally, Hullett Township has moderate to large possible resources of sand and gravel, and may constitute a regional source for road-building and construction material. Care should be taken to ensure the continuing availability of as much of these resources as possible.

Seven areas containing good quality outwash, esker, and ice-contact sand and gravel have been selected for possible resource protection at the primary level. The selected areas constitute the most important aggregate sources in Hullett Township. The Primary Resource Areas cover 2600 acres (1050 ha), of which 1790 acres (720 ha) are considered to be available for extraction. The available areas contain possible resources of 100 million tons (91 million tonnes).

A number of ice-contact sand and gravel deposits have been selected as Resource Areas of Secondary Significance. Although these secondary deposits, are not considered the "best" resources, they should be considered as part of the township's aggregate supply.

The majority of the township is overlain by more than 50 feet (15 m) of drift, although scattered areas of thinner drift do occur. Bedrock in the township consists largely of Dundee Formation limestone, with two small areas of Lucas Formation dolostone. Although the Dundee and Lucas Formations have potential value as sources of crushed stone, the thick drift cover and the availability of surficial sand and gravel combine to make the quarrying of the formations in Hullett Township generally uneconomical.

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Introduction

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1984, the total tonnage of mineral aggregates extracted was 109 million tons (99 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Weatherson 1986).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand and gravel resources as well as a discussion on the potential of bedrock-derived aggregate. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

Part I — Inventory Methods

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References) as well as field examination of potential resource areas. Field methods include the examination of natural and man-made exposures of granular material. Most observations are made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites include estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations are also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, subsurface materials may be assessed by hand augering and test pitting, supplemented by test hole drilling, and geophysical surveys using hammer seismic equipment. The symbols for and locations of sample sites, test hole sites, and geophysical traverse lines are noted on Map 1.

Deposits with potential for further extractive development or those where existing data are scarce, are studied in greater detail. Representative layers in these deposits are sampled in 25- to 100-pound (11- to 45-kg) units from existing pit faces or from test pits. The samples are analysed for grain size distribution, and in some cases Los Angeles abrasion, absorption, and Magnesium Sulphate soundness tests and petrographic analyses are carried out. Analyses are performed either in the laboratories of the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications, or in the Geoscience Laboratories, Geoservices Section, Ontario Geological Survey.

The field data are supplemented by pit information on file with the Soils and Aggregates Section of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under the Pits and Quarries Control Act are obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Aerial photographs at various scales are used to determine the continuity of deposits, especially in areas where information is limited. Water well records, held by the Ontario Ministry of the Environment, are used in some areas to corroborate deposit thickness estimates or to indicate the presence of buried granular material. These records are used in conjunction with other evidence.

Topographic maps of the National Topographic System, at a scale of 1:50 000, are used as a compilation base for the field and office data. The information is then transferred to a base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been established, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable because of the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside and abandoned pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage (Column 7) presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however the aggregate potential of these deposits is discussed in the report.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography

maps, and from the interpretation of water well records. The measured extent of such areas is then multiplied by the estimated quarriable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of 60 feet (18 m) is used for thickness. Volume estimates are then multiplied by the density factor (the estimated weight in tons of a one-foot (0. 3 m) thick section of rock, one acre (0.4 ha) in extent).

Resources of dolostone are calculated using a density factor of 165 pounds per cubic foot (2649 kg per cubic metre) or 3600 tons per acre (8070 tonnes per hectare). Sandstone resources are calculated using a density estimate of 146 pounds per cubic foot (2344 kg per cubic metre) and shale resources are calculated with a factor of 150 pounds per cubic foot (2408 kg per cubic metre).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel deposits are termed possible resources (see Glossary, Appendix B) in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976).

Part II — Data Presentation and Interpretation

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources" shows the distribution of bedrock formations, the thickness of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

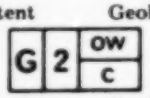
Map 1 is derived from existing surficial geology maps of the area or from aerial photograph interpretation in areas where surficial mapping is incomplete. The map shows the extent and quality of sand and gravel deposits within the study area and the present level of extractive activity.

On the map, gravel deposits are indicated by dark brown shading while sand deposits are shaded light brown. The present level of extractive activity is also indicated. Those areas which are licenced for extraction under the Pits and Quarries Control Act are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or wayside pits operating on demand under authority of a permit) are identified by a numbered dot on Map 1 and described in Table 2. Similarly, test hole locations appear on Map 1 as a point symbol and are described in Table 7. Geophysics lines are shown on Map 1 by a line symbol and are interpreted in Table 8.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Map 1. These components are illustated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35 percent of the whole deposit. "G" indicates that the deposit contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution of material sampled during field study. These symbols are derived from the information plotted on the aggregate grading curves found in the report. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically in the Texture Symbol by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary; secondary; and tertiary. Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by dark red shading on Map 2.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by light red shading on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resources in the report area, they may contain large quanitities of sand and gravel and should be considered as part of the aggregate supply of the area.

Areas of tertiary significance are outlined on the map by a solid line but have no shading. They are not considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1 (greater than 20 feet (6 m) thick), and containing more than 35 percent gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

Aggregate Quality

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the deposit symbols on Map 1. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the quality indicators deal with grain size distribution. The gravel content (G or S) indicates the suitability of aggregate for various uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (nigh silt and clay content) may severely limit the potential use of a deposit. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

Another indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock types determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol shows either "C", "O", or "L" or any combination of these indicators, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt is made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of both the Ontario Ministry of Transportation and Communications (M.T.C.) and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Quality data may also appear in Table 9, where the results of M.T.C. quality tests are listed by test type and sample location. The types of tests conducted and the test specifications are explained in Appendices B and E, respectively.

Analyses of unprocessed samples obtained from test holes, pits or sample sites are plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products: Granular Base Course A, B and C; Hot-Laid Asphaltic Sand Nos. 1,2,3,4, and 8; and concrete sand. By plotting

the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product. These graphs, called Aggregate Grading Curves, follow the tables in the report.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalites with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, drift thickness and bedrock topography maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources) and from geotechnical test hole data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of these areas of thin drift are shown by three shades of blue. The darkest shade indicates where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas consitute potential resource areas because of their easy access. The medium shade indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these zones also represent potential resource areas. The lightest shade indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas, the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the report area. Those areas which are licenced for extraction under the Pits and Quarries Control Act are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, licenced acreage and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating on demand under authority of a permit) are also identified and numbered on Map 3 and described in Table 5. Two additional symbols may appear on the map. An open dot indicates the location of a selected water well which penetrates bedrock. The overburden thickness is shown in feet beside the open dot. Similarly, test hole locations appear as a point symbol with the depth to bedrock shown in feet beside it. The test holes may be described further in Table 7.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario

Ministry of Transportation and Communications. The main characteristics and uses of the bedrock units found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource are usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of Bedrock Resource Areas has been restricted to a single level of significance. Three factors support this approach. First, quality and quantity variations are gradual. Second, the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and third, since crushod bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The Selected Areas, if present, are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Part III — Assessment of Aggregate Resources in Hullett Township

LOCATION AND POPULATION

Hullett Township occupies approximately 53,714 acres (21 738 ha) in central Huron County, southwestern Ontario. The township appears on the Goderich (40 P/12), Lucknow (40 P/13), Seaforth (40 P/11) and Wingham (40 P/14) map sheets of the National Topographic System, at a scale of 1:50 000.

The population of Hullett Township has undergone minor fluctuations in the past several years. From 1972 the population of the township decreased by 2 percent to a total of 1900 in 1982 (Ontario Ministry of Municipal Affairs and Housing 1984; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). Land use is predominantly agricultural, with some extractive and recreational activities. A large wildlife management area, managed by the Ontario Ministry of Natural Resources, is located in southeastern Hullett Township.

The Town of Clinton, located in the southwestern corner of the township, is the largest urban centre in the area. In 1982, the town had a population of 3052 (Ontario Ministry of Municipal Affairs and Housing 1984). The town provides commercial, industrial and institutional services to the surrounding population.

The Village of Blyth, located along the northern boundary of the township, also serves as a nucleus for commercial and agriculturally related industrial activities. The major industry in Blyth is the processing, manufacturing, and sale of wool and leather goods (County of Huron Planning Board 1981). The population of the village was 931 in 1982 (Ontario Ministry of Municipal Affairs and Housing 1984). The village is expected to experience moderate population growth (County of Huron Planning Board 1981). The hamlets of Auburn, Londesborough, and Kinburn also provide services to the local population.

Access to the township is provided by King's Highway 8, which forms the township's southern boundary, and King's Highway 4 which runs northeast-southwest through central Hullett. Various county and township roads provide connecting links within the township. A Canadian National Railways line connects Clinton with Goderich to the northwest, and with Seaforth and Mitchell to the southeast. At the present time, freight service runs several times a week on this line. Freight service runs daily through Goderich, Blyth and West Monkton on a Canadian Pacific Railway line located along the northern boundary of the township.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

Approximately 23 000 years ago, during the Late Wisconsinan Substage of the Pleistocene Epoch (informally known as the "Great Ice Age"), lobes or submasses of the Laurentide continental ice sheet advanced out of the Lake Huron and Georgian Bay lake basins to cover this area. The lateral extent of these ice lobes and the positions of the respective ice margins underwent numerous fluctuations until approximately 10 000 years ago when the ice finally melted and completely disappeared. The physiography and distribution of surficial materials in Hullett Township, and specifically the sand and gravel deposits shown on Map 1 of this report, are the result of the oscillations of the Georgian Bay and Huron ice fronts during that period.

The physiography of Hullett Township is dominated by a broad expanse of very hummocky terrain which encompasses most of the western two thirds of the township. This landscape is the surface expression of the Wawanosh Moraine, part of the Horseshoe Moraines system (Chapman and Putnam 1984). The moraine, which is orientated in a north-south direction along the western boundary of the township, was formed by the interaction of the Georgian Bay and the Huron ice lobes. The development of the moraine is closely linked to the deposition of the two surface tills found in the township.

The Georgian Bay lobe advanced into Hullett Township from the north-northeast and deposited the Elma Till, a hard, stony, sandy silt till (Cooper and Fitzgerald 1977). The Georgian Bay lobe stood at or just east of the Wawanosh Moraine area, while the Huron lobe stood just west of it. Large quantities of sand and gravel were deposited between the two lobes, forming the Wawanosh Moraine (Cooper and Fitzgerald 1977). The ice-contact sediments which make up the moraine are the largest source of sand and gravel in Hullett Township. The ice-contact material is found throughout the township, either exposed at the surface or buried under other sediments (Cooper 1976a) (Map 1).

After the Wawanosh Moraine was formed, the Georgian Bay lobe melted back and the Huron lobe overrode the moraine and advanced to the east. During this advance the Rannoch Till was deposited (Cooper et al. 1977). The Rannoch Till is a variable, loose, stony silt till. Although it is patchy in western Hullett, in the eastern part of the township it forms a continuous, undulating plain, part of the Stratford Till Plain (Chapman and Putnam 1984).

The Rannoch Till is up to 30 feet (9 m) thick in places, and overlies the Elma Till and the ice-contact sediments of the Wawanosh Moraine creating many buried sand and gravel deposits (Cooper 1976a). Very little is known about these deposits although their ice-contact origin indicates a variable nature. These deposits would not likely be economical sources of aggregate as significant quantities of similar material are available at the surface elsewhere in the township.

The advance of the Huron lobe also resulted in the formation of the Seaforth Moraine. A small portion of the moraine occurs in southeastern Hullett where it joins with the Wawanosh Moraine. The Seaforth Moraine is largely ice-contact stratified drift capped by Rannoch Till (Cooper 1975).

Approximately 13 500 years ago the Huron lobe melted back into the Huron Basin, west of Hullett Township (Cooper and Fitzgerald 1977). Two eskers were deposited in central Hullett at that time. The Londesborough and the South Maitland Eskers (Cooper 1976a) trend roughly in an east-west direction. The eskers generally contain better sorted material than undifferentiated ice-contact stratified drift,

and have a higher probability of containing crushable aggregate. Past extraction in the two eskers has proven them to be valuable sources of sand and gravel.

Meltwaters draining away from the wasting ice lobes formed numerous small outwash deposits throughout the township. Shallow predominantly sandy deposits with limited use potential occur in the township's creek and river valleys (Cooper 1976a). One relatively large terrace on the South Maitland River near Auburn is a good source of gravel and may be the most valuable source of aggregate in the township.

Ponding of meltwaters resulted in the deposition of lacustrine sediments in the low-lying areas of the township. The sediments consist of fine sand, silt, and clay, and are generally too fine grained for use as aggregate.

EXTRACTIVE ACTIVITY

In 1981 Hullett Township was designated under the Pits and Quarries Control Act. Prior to that time a number of pits had been operating on a casual basis throughout the township. Forty-four pits (for which information is available) have been identified in this report and their locations are shown on Maps 1 and 2. Most of these pits are now inactive (abandoned). Twenty-nine of the pits have been rated by the Ontario Ministry of Transportation and Communications (M.T.C.) on their ability to supply road-building and construction aggregrate. Two thirds of the pits received "moderate" to "moderate-high" pit use ratings, indicating that they can provide aggregate for use in the production of Granular Base Course (G.B.C.) A, and in some cases, Hot-Laid (H.L.) No. 4 asphaltic stone. The remaining pits received "low" ratings, and are capable of supplying G.B.C. B and C (Deike 1982).

At the time of writing there are 11 pits licenced for extraction under the Pits and Quarries Control Act. The total area of all the licenced properties in Hullett Township is 565.28 acres (228.77 ha). Records on file at the Wingham District Office of the Ontario Ministry of Natural Resources indicate that in 1982 a combined total of 103,678 tons (94 057 tonnes) of aggregate was extracted from the licenced sources in the township.

SELECTED SAND AND GRAVEL RESOURCE AREAS

Hullett Township contains approximately 46,000 acres (18 600 ha) of sand and gravel deposits. The total estimated tonnage in these deposits is 1920 million tons (1740 million tonnes). Seven of the deposits have been selected for protection at the primary level. The Primary Resource Areas cover approximately 2600 acres (1050 ha), exclusive of licensed properties. An estimated 1790 acres (720 ha) are considered to be available for extraction, containing approximately 100 million tons (91 million tonnes) of sand and gravel. The available portions of the Primary Resource Areas represent 4 percent of the total area of sand and gravel deposits in Hullett, and 5 percent of the total tonnage.

Several ice-contact deposits have been designated for secondary resource protection. The secondary deposits serve as important alternate extraction sites, and should be considered part of the total aggregate supply.

The results of past M.T.C. testing in 29 of the 45 pits identified in this study indicate that generally, the quality of sand and gravel in Hullett Township is good. Many of the samples tested by M.T.C. met the gradation specifications for granular base course, hot-laid asphalt, and concrete products (Deike 1982). The amount of crushable gravel in most tested pits was satisfactory, however, much of the sand fraction was coarsely graded (Deike 1982). Coarsely graded sand tends to be of poorer quality than finer sand, and is unstable in many aggregate mixes.

Hullett Township is located between two chert-prone sectors of southwestern Ontario. In most of the pits tested by M.T.C., Petrographic Numbers averaged from 112 to 130, indicating that the gravel was petrographically suitable for use in granular base course, 16 mm crushed products, H.L. 4, 5, 6 and 8 asphaltic aggregate, and concrete (Deike 1982). Petrographic test results from several pits, however, reflected the presence of undesirable materials, often chert, which is unacceptable for use in most hot-laid asphaltic, and all concrete aggregate. Test results may be improved by selective extraction within a particular pit, and/or by crushing oversize material and adding it to the aggregate to dilute the undesirable characteristics of the material to acceptable levels (Deike 1982).

Additional tests performed by M.T.C. on the township's aggregate include Magnesium Sulphate Soundness, Los Angeles Abrasion and Absorption tests. The results from the Magnesium Sulphate Soundness test and the Los Angeles Abrasion test are expressed as percent weight loss, whereas the results of the test for Absorption are expressed as percent weight gained. The maximum allowable gains and losses, as well as the maximum allowable petrographic numbers for the various types of aggregate are shown in Appendix E. Table 9 shows the results of M.T.C. testing in selected pits in Hullett Township.

The average weight loss during the Magnesium Sulphate Soundness test for the coarse fraction of samples taken from Hullett Township was 2.7 to 5.9 percent (Deike 1982), well within the ranges for most products. Some samples did exceed 12 percent losses and represented sources which would be unsuitable for hot-laid and concrete stone products. Samples averaged 22 to 27 percent losses during the Los Angeles Abrasion test (Deike 1982), which are acceptable losses for most products. When subjected to Absorbtion testing, samples taken from Hullett Township had average weight gains of 1.3 to 1.9 percent (Deike 1982) which are acceptable for H.L. 4 and 8, concrete products, and in some cases H.L. 3 asphaltic aggregate. Some samples exhibited weight gains of 2.1 to 2.9 percent (Deike 1982) and represented sources that were not suitable for concrete or hot-laid products.

In general, the aggregate in the township is hard and durable, and suitable for a variety of aggregate uses including asphalt and concrete products. In

some pits, however, the gravel quality is borderline and the sand fraction grades coarse for higher specification uses.

SAND AND GRAVEL RESOURCE AREAS 1 AND 5

Selected Sand and Gravel Resource Areas 1 and 5 are both outwash gravel deposits. Resource Area 1 occupies approximately 580 acres (235 ha) along the east bank of the Maitland River, southwest of Auburn. Resource Area 5 occupies approximately 55 acres (22 ha) on the north bank of the South Maitland River, just east of Summerhill.

Resource Area 1 contains abandoned pit 12 and licenced pit 1. At the time of observation, pit 12 was overgrown and partially water filled. The pit face extended 5 to 7 feet (1.5 to 2 m) above the waterline. The pit had previously been extracted to a depth of approximately 8 to 9 feet (2 to 3 m) (Hullett Township Roads Superintendant, personal communication. 1982). Licenced pit 1 had a 10-foot (3 m) face which exposed well stratified coarse to fine gravel with coarse to fine sand and a little silt. The pit contained an estimated 50 to 70 percent gravel, with approximately 5 percent of the gravel fraction being oversize (greater than 10 cm). Backhoe testing carried out by Hullett Township in licenced pit 1 indicated an additional 10 to 12 feet (3 m) of gravel below the pit floor. The gravel appeared to become slightly coarser with depth (Hullett Township Roads Superintendent, personal communication, 1982).

A sample taken from the pit contained 77 percent gravel, 21 percent sand, and 2 percent fines (Figure 2a). Approximately 43 percent of the aggregate in the sample was larger than 26.5 mm in size, making the gravel crushable. The material in the sample could meet the gradation requirements of G.B.C. A and 16 mm Crushed Type A and B with crushing and screening, but was borderline for G.B.C. B and C because it lacked fines for binder. The sample also met the gradation requirements of H.L. 2 sand, and with blending could meet H.L. 1, 3, 4, and 8, and concrete requirements (Figure 2b). G.B.C. A, produced with a portable crusher, is currently the highest quality aggregate product produced from licenced pit 1 (Hullett Township Roads Superintendant, personal communication, 1982).

Care should be exercised in extrapolating the data from one pit to an entire deposit. However, given the relatively uniform nature of outwash deposits, and the gradation data previously discussed, Resource Area 1 is considered to be a source of good to high quality aggregate. A high water table may pose problems for extraction in Area 1.

Selected Resource Area 1 contains an estimated 285 acres (115 ha) of outwash gravel available for extraction. Based on an average thickness of 15 feet (5 m), the deposit contains approximately 11 million tons (10 million tonnes) of sand and gravel. The deposit is accessible by County Roads 8 and 25, and various township roads. A line of the Canadian Pacific Railway crosses Area 1.

Selected Resource Area 5 contains no licenced or abandoned pits. A water well located within the deposit was drilled through 4 feet (1.2 m) of sand overlying 32 feet (10 m) of gravel. Although there is limited data available for this deposit, it has been selected because of its expected geological characteristics based on its mode of origin.

Selected Resource Area 5 contains approximately 40 acres (16 ha) available for extraction. Assuming an average thickness of 15 feet (5 m), the deposit contains approximately 1 million tons (1 million tonnes) of sand and gravel. Resource Area 5 is accessible from King's Highway 4, County Road 8, and various township roads.

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Selected Sand and Gravel Resource Area 2 is an ice-contact gravel deposit occupying approximately 990 acres (400 ha), exclusive of licenced properties. The deposit, which extends into East Wawanosh and Morris Townships, is part of the Wawanosh Moraine.

Both licenced pits 2 and 3 are located in Resource Area 2. Licenced pit 2 is a large pit with 15- to 50-foot (5 to 15 m) faces. Pit faces exhibited the variability that is characteristic of ice-contact deposits. A section of the west face revealed coarse to fine gravel with coarse sand, some medium to fine sand, and a trace silt. In places the northeast face contained silty fine to medium sand with a little coarse and medium sand and a trace of fine gravel. Samples were taken from these two faces and analysed. The results are shown on Figures 2a and 2b. Sample 2a (west face) was a crushable sample containing 72 percent gravel, 26 percent sand, and 2 percent fines. In terms of gradation, the material would be suitable for use in G.B.C. A and 16 mm Crushed Type A and B with crushing and screening. Blending would be required for production of asphaltic and concrete sand. The material was very clean (2 percent fines) and was therefore borderline for use as G.B.C. B and C because of lack of binder. Sample 2b (northeast face) contained 40 percent gravel. 38 percent of which was greater than 26.5 mm in size. The sample also contained 52 percent sand and 8 percent fines. Overall, the sample was only suitable for use as select subgrade or G.B.C. C because of its fine sand content.

Data obtained from M.T.C. for licenced pit 2 indicate that the pit contains 25 to 75 percent gravel, 6 to 55 percent of which is greater than 1 inch (25 mm), and up to 15 percent of which is oversize (Deike 1982). The pit is rated as being able to produce G.B.C. A, B and C, 16 mm Crushed Type A and B, H.L. 4 and 8 stone, and hot-laid sand products with blending. The quality of the gravel in the pit is borderline for asphalt and concrete uses (Table 9). A chert content of up to 15 percent in the coarse fraction is the major factor limiting gravel quality. Silt seams are present in the pit and in sections the sand grades too fine for use in hot-laid products.

Licenced pit 3 is located adjacent to, and at a higher elevation than pit 2. At the time of observation, pit 3 had a 20-foot (6 m) face and contained an estimated 40 to 70 percent gravel, 5 to 15 percent of which is oversize. A sample taken from this pit was found to contain 69 percent gravel, 30 percent sand, and 1 percent fines (Figure 3a). According to its gradation characteristics products such as granular

base course, 16 mm Crushed Type A, asphaltic sand, and concrete sand may be produced with processing.

Abandoned pit 15 is also located in Resource Area 2. At the time of observation, the pit had a 10-foot (3 m) face and contained an estimated 10 to 65 percent gravel, up to 35 percent of which is greater than 1 inch (25 mm) in size, and up to 2 percent of which is oversize (Deike 1982). The pit contained mainly sand with pockets of crushable material and was rated as being capable of producing G.B.C. A, B and C, and 16 mm Crushed Type B.

Water well records indicate varying depths of sand and/or gravel throughout the deposit. Clay is also sometimes reported. Between 18 feet (6 m) of sand and 70 feet (21 m) of sand, gravel, clay and stones is reported in these wells.

The area available for extraction in Resource Area 2 is approximately 710 acres (285 ha). Assuming an average thickness of 25 feet (8 m) of usable material, the deposit contains an estimated 44 million tons (40 million tonnes) of aggregate. The deposit is accessible from King's Highway 4, and County Road 2. A Canadian Pacific Railway line runs through Blyth directly north of the deposit.

SELECTED SAND AND GRAVEL RESOURCE AREA 3

The South Maitland Esker makes up Resource Area 3. The esker parallels the course of the South Maitland River in central Hullett and was formed during the melting of the Lake Huron ice lobe. Selected Resource Area 3 contains 55 acres (22 ha), exclusive of licenced properties.

Licenced pits 6 and 7 are located in Resource Area 3. At the time of field investigation, both pits contained fine to coarse gravel and clean medium to coarse sand. Pit faces ranged in height from 15 to 30 feet (5 to 9 m) and contained approximately 40 to 60 percent gravel. Licenced pit 7 contains 10 to 15 percent oversize. The material in licenced pit 6 tended to be finer, and the pit contained no appreciable oversize.

A sample collected from licenced pit 7 contained 59 percent gravel, 40 percent sand, and 1 percent fines (Figure 3a). The sample was crushable as 43 percent of the material was larger than 26.5 mm in size. The gradation characteristics of the sample indicate that it may be suitable for use in G.B.C. A, B and C, concrete sand, and hot-laid sand with processing.

Data obtained from M.T.C. for pit 7 indicate that the pit contains 34 to 64 percent gravel, 10 to 28 percent of which is greater than 1 inch (25 mm) and 1 percent of which was oversize (Deike 1982). The pit was rated as being able to produce G.B.C. A, B and C, 16 mm Crushed Type A and B, and hot-laid sand with blending. Sand control was required to produce products from some parts of the pit, and clayey areas were reported. The material in the pit was petrographically suitable for use in most aggregate products. Abrasion, soundness, and absorption tests supported this result (Table 9).

Resource Area 3 also contains abandoned pits 28 and 29. Data provided by M.T.C. for the pits indicated that they had 20- to 30-foot (6 to 9 m) faces. Pit 28 contained 70 percent gravel, 40 percent of which was crushable, and 9 percent of which was oversize (Deike 1982). The pit was rated as being an acceptable source of 16 mm Crushed Type A and B, G.B.C. A, B and C, and select subgrade. The pit contained material petrographically suitable for use in most hot-laid and concrete products. Abrasion, absorption and soundness test results also indicate that the aggregate is of good quality (Table 9).

Pit 29 contained variable amounts of gravel (Deike 1982). It is rated as being able to produce G.B.C. A, B and C, 16 mm Crushed Type A and B, and hot-laid sand with blending. The sand grades coarse and selection is required for crushing.

Selected Resource Area 3 contains approximately 40 acres (16 ha) available for extraction. Given an estimated deposit depth of 25 feet (8 m), Area 3 contains 2 million tons (2 million tonnes) of sand and gravel. The deposit is accessible by various township roads.

SELECTED SAND AND GRAVEL RESOURCE AREA 4

The Londesborough Esker which makes up Resource Area 4 was also formed during the melting of the Lake Huron ice lobe. Abandoned pits 20 and 21 are located in the esker. Both pits were partially overgrown and sloughed over during field inspection. Pit 20 contained fine to coarse gravel with medium sand and some coarse sand and a trace of silt. Gravel content in the pit was estimated to be 40 to 50 percent. The pit face was 5 to 7 feet (1.5 to 2 m) high.

Data obtained from M.T.C. for pit 21 indicate that the pit consisted of 30 to 75 percent gravel (Deike 1982). Sixteen to 60 percent of the gravel fraction was greater than 1 inch (25 mm) in size, while up to 6 percent was oversize. The gravel fraction contained 5.5 percent chert. The presence of oversize material, clay seams, and the fact that washing is required to produce some hot-laid products, were noted as pit workability problems. Pit 21 is rated as being able to produce G.B.C. A, B and C, 16 mm Crushed Type A and B, and hot-laid sand with processing. In terms of quality the material in the pit is suitable for most granular base course, hot-laid stone and concrete stone products (Table 9).

Of the 125 acres (51 ha) which make up Resource Area 4, 110 acres (44 ha) are available for extraction. Assuming an average deposit thickness of 20 feet (6 m), the esker contains 6 million tons (5 million tonnes) of sand and gravel. The deposit is accessible from King's Highway 4 and township roads.

SELECTED SAND AND GRAVEL RESOURCE AREAS 6 AND 7

Selected Sand and Gravel Resource Areas 6 and 7 are both ice-contact gravel deposits. They are part of the Wawanosh and Seaforth Moraines, and are located in southeastern Hullett where the two moraines combine. Excluding licenced properties, Resource Area 6 occupies 290 acres (117 ha) and Resource Area 7 occupies 500 acres (202 ha).

Licenced pit 11 and abandoned pits 37 to 40 occur within the boundaries of Area 6. Licenced pit 11 has multiple faces, 15 to 18 feet (5 to 6 m) in height, some of which are sloughed over. The pit was estimated to contain 20 to 70 percent gravel. The material was variable as is typical of ice-contact stratified drift. Clay and silt seams and oversize material up to 1 foot (0.3 m) in diameter were noted. A sample from pit 11 consisted of 59 percent gravel, 40 percent sand, and 1 percent fines (Figure 4a).

Abandoned pits 37 to 40 have 10- to 30-foot (3 to 9 m) faces and contain up to 50 percent gravel. Pit 37 is rated by M.T.C. as able to produce G.B.C. A, B and C, 16 mm Crushed Type A and B, H.L. 4 and 8 stone, and hot-laid sand with blending (Deike 1982). Pit 38 can produce G.B.C. A, B and C, and 16 mm Crushed Type A and B (Deike 1982). Sand control is required during crushing operations. In terms of petrographic and absorption criteria, the material in the pit is not suitable for use in hot-laid and concrete stone products (Table 9).

Selected Resource Area 7 contains abandoned pits 34 and 35. These pits had 15- to 40-foot (5 to 12 m) faces. Pit 35 contained 45 to 75 percent gravel, 21 to 35 percent of which was larger than 1 inch (25 mm) in size, and up to 6 percent of which was oversize (Deike 1982). The pit contained pockets of clay and silt, and oversize material had to be removed or crushed during processing. According to petrographic and soundness criteria, the material is unsuitable for use in H.L. 1 and 3 stone, and concrete paving stone (Table 9).

Resource Area 6 contains 195 acres (79 ha) available for extraction. The estimated depth of usable material is 20 feet (6 m). The deposit contains 10 million tons (9 million tonnes) of sand and gravel. Area 6 is accessible from King's Highway 8 and township roads.

Approximately 410 acres (166 ha) are available for extraction in Area 7. Given an estimated 25 feet (8 m) of usable material, the deposit contains 26 million tons (24 million tonnes) of sand and gravel. The deposit is accessible from King's Highway 4 and various township roads.

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

A number of ice-contact deposits which are part of the Wawanosh and Seaforth Moraines have been selected as Resource Areas of Secondary Significance. By definition, secondary areas do not contain the best aggregate in the township, however, they may contain large quantities of sand and gravel of lower quality. It is not feasible to identify individual areas of coarse-grained material within the extensive and complex sections of the Wawanosh and Seaforth Moraines which have been outlined as secondary areas. The deposits lack continuity and are extremely variable in grain size. Overall, the secondary areas are expected to be primarily sand deposits although they may contain sizeable gravel resources. Testing is required to delineate areas which may contain aggregate suitable for high specification uses.

In northwestern Hullett, south and southwest of Auburn,there are two ice-contact deposits which have been selected at the secondary level of significance, in which there are no available exposures. In the deposit located south of Primary Resource Area 1 two test holes were drilled. Test hole HU-TH-1 was drilled at the top of a hill in the deposit. Eleven feet (3 m) of silty clay over 20 feet (6 m) of fine to very fine sand with some silt were encountered in this hole. At the bottom of the hill, in test hole HU-TH-2, 5 feet (1.5 m) of clay with some silt and sand were discovered before the drilling was terminated in impenetrable material. Water wells in these deposits showed a minimum 15 to 20 feet (5 to 6 m) of sand and gravel with some stones and clay. Although the data available for these deposits is limited, based on their mode of deposition and the quality of material available from similar deposits in Hullett Township, the deposits are considered possible sources of substantial quantities of low- to moderate-quality aggregate. More detailed testing is required to establish the character of this resource.

A larger ice-contact deposit lies to the east of the previously discussed deposits. This deposit contains abandoned pits 13 and 14. Pit 13 has a 10-foot (3 m) face and contains 20 to 40 percent gravel. Test hole HU-TH-3 drilled in the pit showed 9 feet (3 m) of coarse sand with fine gravel over 5 feet (1.5 m) of wet silt with some medium sand. Pit 14 has a 5- to 15-foot (1.5 to 5 m) face (Deike 1982). M.T.C. data indicate that it contains mostly clean sand with no crushable material. The material lacks fine sand for hot-laid sand and blending is required for this use. The pit can also produce select subgrade and G.B.C. B and C (Deike 1982). Testing is required to determine the physical quality of the material in the pit. Water wells showed predominantly sand and clay, with some stone recorded.

Licenced pit 4 and abandoned pits 17, 18 and 19 are located within one of the larger secondary deposits, west of Londesborough. Licenced pit 4 had a 5- to 15-foot (1.5 to 5 m) face and contained 10 to 40 percent gravel. The face exposed medium sand with some coarse sand and silt and subangular to subrounded coarse to fine gravel. A sample taken from the pit contained 13 percent gravel, 73 percent sand, and 14 percent fines (Figure 3a).The pit is rated by M.T.C. as being able to produce G.B.C. A, B and C, 16 mm Crushed Type A and B, H.L. 4 and 8 stone, and hot-laid sand with blending. Pit workability problems include the presence of silt seams and oversize material along with the poor gradation of the sand fraction as in some sections the sand grades too coarse and in others too fine. The aggregate is petrographically suitable for most hot-laid products and is borderline to acceptable for concrete paving aggregate (Table 9)(Deike 1982).

Abandoned pit 17 contained 30 to 40 percent gravel and had a face height of 25 feet (8 m). The pit face exposed poorly sorted sand with some gravel in pockets. The gravel was predominantly fine, with some coarse gravel and 0 to 5 percent oversize with a maximum size of 8 inches (20 cm). Thick lenses of silt were noted. A number of water wells are located within the deposit, and they record mostly sand and clay, with gravel and stones occasionally noted.

An ice-contact deposit associated with the Londesborough Esker contains abandoned pits 22 and 23. Pit 23 had 5- to 15-foot (1.5 to 5 m) faces, and contained 30 percent gravel (Deike 1982). M.T.C. data indicate that the pit can produce G.B.C. A, B and C. 16 mm Crushed Type B, and hot-laid sand with blending. The presence of chert is noted, and is expected to be higher in the fine fraction than in the coarse fraction. Pit 22 contains mainly sand (Deike 1982).

Abandoned pits 26 and 31 are located in another secondary area. Pit 26 had a face height of 25 feet (8 m) and contained 55 to 70 percent gravel. Twenty-five to 40 percent of the gravel was larger than 1 inch (25 mm) and 4 to 8 percent was oversize (Deike 1982). The pit was rated by M.T.C. as being able to produce G.B.C. A, B and C, 16 mm Crushed Type A and B, and hot-laid sand with blending. Some sections of the pit were dirty. The material in the pit was petrographically unsuitable for use in H.L. 1 stone and concrete paving stone (Table 9)(Deike 1982). Pit 31 had multiple faces which varied from 10 to 25 feet (3 to 8 m) in height. Data obtained from M.T.C. for the pit indicate that it contained 6 to 54 percent gravel, up to 33 percent of which was greater than 1 inch (25 mm) in size, and up to 4 percent was oversize. The pit was rated as being able to produce G.B.C. A, B and C, 16 mm Crushed Type B, and hot-laid sand with blending. Although the pits contained some higher specification aggregate, the deposit was generally variable, containing only minor amounts of crushable material and able to supply mainly sandy G.B.C. B (Deike 1982). Water well records revealed variable amounts of sand and clay, with boulders encountered occasionally.

Abandoned pits 24 and 25 are located in a smaller ice-contact deposit east of Summerhill. Pit 25 had a 15-foot (5 m) face and contained up to 30 percent gravel, with 0 to 2 percent being larger than 1 inch (25 mm) (Deike 1982). The pit was rated as being able to produce G.B.C. B and C with selection. Another small ice-contact sand deposit in the vicinity of Clinton contains abandoned pit 33 which had an overgrown 25-foot (8 m) face. A water well in the deposit shows 83 feet (25 m) of sand.

A large ice-contact deposit located in southern Hullett contains abandoned pits 36, 41 and 42. Pits 41 and 42 contain 10 to 30 percent gravel and had 10- to 15-foot (3 to 5 m) faces. M.T.C. data reveal that pit 36 had a 45-foot (14 m) face and contained 20 percent gravel (Deike 1982). Sixty percent of the gravel fraction was greater than 1 inch (25 mm) in size, and 25 percent was oversize. The pit is rated as being able to produce G.B.C. A, B and C, 16 mm Crushed Type A and B, and H.L. 4 and 8 stone. Sand control would be required for crushing (Deike 1982).

Several other small ice-contact sand deposits have been chosen as secondary areas in Hullett Township. Although sub-surface data are lacking for these deposits, they were deposited in a similar geological environment as the ice-contact features previously described. Therefore, they are expected to contain similar materials. Further testing will be required, however, to establish their full resource potential.

One ice-contact-esker deposit which is part of the Winthrop Esker (Cooper 1976b) runs approximately east-west through McKillop Township and into Hullett along the eastern border of the township. The ice-contact section of this complex in Hullett Township may be a valuable source of aggregate and has been selected as a secondary area.

BEDROCK GEOLOGY

The Middle Devonian Dundee Formation and the Lower-Middle Devonian Lucas Formation of the Detroit River Group underlie the surficial deposits in Hullett Township. The nomenclature history of these formations is complex and the following discussion is based on the work of Uyeno, Telford and Sanford (1982, pp. 9-15).

Two relatively small areas of the Lucas Formation of the Detroit River Group are located along the northern and eastern boundaries of the township. In Ontario the formation can be subdivided into undifferentiated Lucas Formation and the Anderdon Member of the Lucas Formation. The Anderdon Member is a very high purity limestone which is quarried near Ingersoll and Amherstburg for use in the production of flux stone, lime and portland cement. Undifferentiated Lucas Formation, which underlies Hullett Township, consists of thin- to medium-bedded, light brown to grey-brown, finely crystalline, poorly fossiliferous dolostone with minor chert, dark bituminous laminations, and local mottling. Undifferentiated Lucas Formation is not used in lime and cement production. It is quarried at Amherstburg for crushed stone, and is a borderline to acceptable source of granular base course products and sub-base course products. Problems with excessive fines, and high absorption and soundness losses have been experienced with some of this material (Koniuszy and Katona 1981). Testing would be required to establish the quality of the Lucas Formation in Hullett.

The younger Dundee Formation underlies most of the township. The Dundee Formation is a medium- to thick-bedded, dark brown, fossiliferous, micritic limestone which contains bituminous laminations, shale partings, chert nodules and lenses of coarse-grained bioclastic limestone. The formation is quarried for use in the production of portland cement at St. Marys. Generally, the Dundee Formation limestone that is quarried as crushed stone in southwestern Ontario tends to be soft, has L.A. abrasion test results of 22 to 32 percent, generally is sound and has absorption test values as high as 4 percent (Hewitt 1960). No quarries have been opened in the formation north of St. Marys, and there is little data concerning the possible uses of the formation in this area. The suitability of the bedrock for use in the production of crushed stone products or portland cement can only be established by testing.

Bedrock is covered by relatively thick drift in Hullett Township. Small areas of less than 50 feet (15 m) of drift are scattered throughout the township. However, no areas of bedrock were selected for possible resource protection because the excessive drift thickness would render quarrying uneconomical.

Cooper (1976a) has suggested that bedrock is probably within 25 feet (8 m) of the surface in the

area along the Maitland River southwest of Auburn. The overburden in this area is the gravel outwash of Selected Resource Area 1. If the bedrock is found to be within quarrying distance of the surface and is suitable, the area could have potential as not only a source of surficial sand and gravel but also as a possible source of bedrock for use in the manufacture of crushed stone and portland cement. High water levels may pose problems for extraction.

SUMMARY

Substantial quantities of sand and gravel were deposited in Hullett Township during the Great Ice Age. Testing has shown that the quality of this material is generally good. The amount of crushable gravel in most tested pits is satisfactory, however, the sand fraction is often coarsely graded (Deike 1982). Although Hullett is located between two chert-prone areas, tests show that the presence of deleterious materials is not a major problem in the township.

Several ice-contact, esker, and outwash deposits have been selected for possible resource protection at the primary level. In addition, several ice-contact deposits have been selected at the secondary level. The selected deposits contain significant resources of sand and gravel suitable for use in a variety of road-building and construction products. They should be able to meet aggregate demands for a considerable period of time.

Most of the township is underlain by limestone of the Dundee Formation. Two small sections of the township are underlain by dolostone of the Lucas Formation. Both formations may be suitable for use as crushed stone, however, most of the township is thickly drift covered and for that reason no bedrock resource areas were selected.

Enquiries regarding the Aggregate Resources Inventory of Hullett Township may be directed to the Aggregate Assessment Office, Ontario Geological Survey, Ministry of Northern Development and Mines at Room M1B-45, Macdonald Block, Queen's Park, Toronto, Ontario, M7A 1W3, (Tel. (416) 965-1663), or to the Ontario Ministry of Natural Resources either at the Wingham District Office, R.R. #5, Wingham, Ontario, N0G 2W0 (Tel. (519) 357-3131) or at the Southwestern Region Office, 458 Central Avenue, London, Ontario, N6B 2E5 (Tel. (519) 433-8431).

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, HULLETT TOWNSHIP*.

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
1	G-E	215 (87)	12 (11)
	G-IC	1500 (610)	90 (82)
	S-IC	12,400 (5000)	620 (560)
	S-IC (buried)	800 (325)	44 (40)
2	S-E	25 (10)	1 (1)
	G-IC	260 (105)	12 (11)
	S-IC	2600 (1050)	111 (101)
	S-IC (buried)	19,900 (8100)	800 (730)
	S-LP	4400 (1780)	148 (134)
	G-OW	660 (265)	25 (22)
	S-OW	96 (39)	4 (4)
3	S-LP	610 (247)	12 (11)
	S-OW	2380 (960)	45 (41)
		46,000 (18 600)	1920 (1740)

N.B. Minor variations in all tables are caused by rounding of data.

*Identified deposit areas within the Town of Clinton have been omitted on all tables.

TABLE 2. SAND AND GRAVEL PITS, HULLETT TOWNSHIP.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet (Metres)	8 % Gravel
LICENCED PITS							
1	-	Township of Hullett	Pt.12	WN SR	31.37 (12.70)	10 (3)	50-70
2	S4-9 S4-86	G. Radford Const. Ltd.	Pt.26	14	13.34 (5.40)	15-50 (5-15)	25-75
3	-	Carl Nesbitt	25	14	31.67 (12.82)	20 (6)	40-70
4	G4-86	George Hoggart	31,32	11	28.65 (11.59)	5-15 (1.5-5)	10-40
5	-	John Weirsma	Pt.4,5	14	122.00 (49.37)	20 (6)	20-30
6	S4-29	Howard Cartwright	Pt.18	8	10.13 (4.10)	15-20 (5-6)	40-50
7	S4-38	G. Radford Const. Ltd.	Pt.18	8	74.84 (30.29)	15-30 (5-9)	50-60
8	-	Arnold Riley	Pt.15	9	4.94 (2.00)	10 (3)	20-30
9	S4-44	Keith W. Connolly	Pt.12	10	98.16 (39.72)	10 (3)	15-40
10	G4-84	G. Radford Const. Ltd.	Pt.24	5	80.28 (32.49)	10-15 (3-5)	20-30
11	S4-85	G. Radford Const. Ltd.	Pt.12	2	69.90 (28.29)	15-18 (5-6)	20-70
					565.28 (228.77)		
UNLICENCED PITS*							
12	-	Unknown	9	WN SR		5-7 (1.5-2)	- (overgrown, waterfilled)
13	-	W. Vincent	33	13		10 (3)	20-40 (partially overgrown)
14	S4-59	P. Youngblut	30	14		5-15 (1.5-5)	-
15	S4-106	L. Popp	25	14		10 (3)	10-65 (partially overgrown)
16	S4-98	N. Knapp	25	13		20 (6)	-
17	-	Unknown	34	10		25 (8)	30-40
18	S4-84	E. Joshling	30	11		15 (5)	- (overgrown)
19	-	Unknown	29	9		5-7 (1.5-2)	-

*Abandoned pits or wayside pits operating on demand under authority of a permit.

TABLE 2. SAND AND GRAVEL PITS, HULLETT TOWNSHIP.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet (Metres)	8 % Gravel
20	-	Unknown	21	10		5-7 (1.5-2)	40-50 (partially overgrown)
21	S4-62	Fangan	18	11		10-30 (3-9)	30-75 (partially overgrown)
22	S4-39	Sanderson	18	11		-	- (overgrown)
23	S4-67	Caldwell	18,19	12		5-15 (1.5-5)	30 (overgrown)
24	-	Unknown	28	8		10 (3)	- (overgrown)
25	G4-97	Snell	26	8		15 (5)	0-30 (overgrown)
26	S4-96	I. Carter	25	8		25 (8)	55-70 (overgrown)
27	-	Unknown	24	9		8-10 (2-3)	10-15 (partially overgrown)
28	S4-19	M. Roy	18	9		30 (9)	70 (partially overgrown)
29	S4-32	Adams	17	9		20-30 (6-9)	- (partially overgrown)
30	S4-63	Carter	11	10		15 (5)	20 (overgrown)
31	S4-93	Finch	20	7		10-25 (3-8)	6-54 (partially overgrown)
32	S4-117	Tibbetts	16	8		15-18 (5-6)	0-5
33	-	Unknown	24	2		25 (8)	- (overgrown)
34	-	Unknown	20	3		15 (5)	- (partially overgrown)
35	G4-85	T. Taylor	20	3		20-40 (6-12)	45-75 (partially overgrown)
36	S4-131	Radford	14	1		45 (14)	20 (overgrown)
37	S4-53	C. Dale	12	2		20-30 (6-9)	20-50 (overgrown)
38	S4-41	M. Dale	11	2		30 (9)	10-20
39	-	Unknown	12	2		15 (5)	- (overgrown)
40	-	Unknown	11	1		10-15 (3-5)	- (overgrown)

TABLE 2. SAND AND GRAVEL PITS, HULLETT TOWNSHIP.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet (Metres)	8 % Gravel
41	S4-52	N. Glazier	13	1		15 (5)	30 (partially overgrown)
42	S4-45	Glazier	12	1		10 (3)	10 (partially rehabili-tated)
43	S4-18	Fowler	4	1		15-20 (5-6)	10-50 (overgrown)
44	S4-58	Fowler	4	1		9 (3)	- (overgrown)

TABLE 3. SELECTED SAND AND GRAVEL RESOURCE AREAS, HULLETT TOWNSHIP.

1 Deposit No.	2 Unlicenced Area Acres (Hectares)	3 Cultural Setbacks Acres (Hectares)	4 Extracted Area Acres (Hectares)	5 Available Area Acres (Hectares)	6 Estimated Deposit Thickness Feet (Metres)	7 Available Aggregate Millions of Tons (Tonnes)
1	580 (235)	290 (117)	5 (2)	285 (115)	15 (5)	11 (10)
2	990 (400)	275 (111)	5 (2)	710 (285)	25 (8)	44 (40)
3	55 (22)	10 (4)	5 (2)	40 (16)	25 (8)	2 (2)
4	125 (51)	10 (4)	5 (2)	110 (44)	20 (6)	6 (5)
5	55 (22)	15 (6)	0 (0)	40 (16)	15 (5)	1 (1)
6	290 (117)	85 (34)	10 (4)	195 (79)	20 (6)	10 (9)
7	500 (202)	85 (34)	5 (2)	410 (166)	25 (8)	26 (24)
	2600 (1050)	770 (310)	35 (14)	1790 (720)		100 (91)

TABLE 4. TOTAL IDENTIFIED BEDROCK RESOURCES, HULLETT TOWNSHIP.

1 **DRIFT THICKNESS** Feet (Metres)	2 **FORMATION**	3 **ESTIMATED DEPOSIT THICKNESS** Feet (Metres)	4 **AREAL EXTENT** Acres (Hectares)	5 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
3-25 (1- 8)	Dundee	40 (12)	2 (1)	<1 (<1)
25-50 (8-15)	Dundee	40 (12)	3600 (1460)	520 (470)
25-50 (8-15)	Detroit River Group (Lucas Formation)	60 (18)	300 (121)	65 (59)
			3900 (1580)	580 (530)

TABLE 5. QUARRIES, HULLETT TOWNSHIP.

1 **NO.**	2 **MTC NO.**	3 **OWNER/ OPERATOR**	4 **LOT**	5 **CON.**	6 **LICENCED AREA** Acres (Hectares)	7 **FACE HEIGHT** Feet (Metres)

-NONE-

TABLE 6. SELECTED BEDROCK RESOURCE AREAS, HULLETT TOWNSHIP.

1 **DEPOSIT NO.**	2 **DEPTH OF OVERBURDEN** Feet (Metres)	3 **UNLICENCED AREA** Acres (Hectares)	4 **CULTURAL SETBACKS** Acres (Hectares)	5 **EXTRACTED AREA** Acres (Hectares)	6 **AVAILABLE AREA** Acres (Hectares)	7 **ESTIMATED WORKABLE THICKNESS** Feet (Metres)	8 **AVAILABLE RESOURCES** Millions of Tons (Tonnes)

-NONE-

TABLE 7. SUMMARY OF TEST HOLE DATA, HULLETT TOWNSHIP.

Test Hole Number: HU-TH-1
Location: Lot 6, Conc. West of North and South Road
Elevation: Approximately 950 feet (290 m) a.s.l.
Date: November 3, 1982

Depth feet (metres)	Description
0-11 (0-3)	silty **clay**
11-20 (3-6)	silty fine **sand**
20-26 (6-8)	very fine **sand** with some silt
26-31 (8-9)	silty very fine **sand**

Test Hole Number: HU-TH-2
Location: Lot 6, Conc. West of North and South Road
Elevation: Approximately 900 feet (274 m) a.s.l.
Date: November 3, 1982

Depth feet (metres)	Description
0-5 (0-1.5)	**clay** with some silt and medium sand
	hole terminated at 5 feet (1.5 m) because drill would not penetrate underlying material

Test Hole Number: HU-TH-3
Location: Lot 34, Conc. 13
Elevation: Approximately 975 feet (297 m) a.s.l.
Date: November 4, 1982

Depth feet (metres)	Description
0-9 (0-3)	coarse **sand** with fine gravel and some medium sand and trace fine sand
9-14 (3-4)	wet **silt** with some medium sand
	hole terminated at 14 feet (4 m) because of water in hole

Test Hole Number: HU-TH-4
Location: Lot 20, Conc. 9
Elevation: Approximately 975 feet (297 m) a.s.l.
Date: November 4, 1982

Depth feet (metres)	Description
0-10 (0-3)	light brown clayey **silt** to silty **clay**
	hole terminated at 10 feet (3 m) because drill would not penetrate underlying material

Test Hole Number: HU-TH-5
Location: Lot 5, Conc. 13
Elevation: Approximately 1074 feet (327 m) a.s.l.
Source: From files of Petroleum Resources Section, M.N.R.

Depth feet (metres)	Description
0-48 (0-15)	drift
48-53 (15-16)	Dundee Formation
53-393 (16-120)	Detroit River Group
393-578 (120-176)	Bois Blanc Formation
	test hole continued to 1811 feet (552 m), dry hole, abandoned

Test Hole Number: HU-TH-6
Location: Lot 5, Conc. 13
Elevation: Approximately 1064 feet (324 m) a.s.l.
Source: From files of Petroleum Resources Section, M.N.R.

Depth feet (metres)	Description
0-46 (0-14)	drift
46-53 (14-16)	Dundee Formation
53-388 (16-118)	Detroit River Group
388-602 (118-183)	Bois Blanc Formation
	test hole continued to 1655 feet (504 m), dry hole, abandoned

Test Hole Number: HU-TH-7
Location: Lot 12, Conc. 11
Elevation: Approximately 1032 feet (315 m) a.s.l.
Source: From files of Petroleum Resources Section, M.N.R.

Depth feet (metres)	Description
0-59 (0-18)	drift
59-82 (18-25)	Dundee Formation
82-482 (25-147)	Detroit River Group
482-622 (147-190)	Bois Blanc Formation
	test hole continued to 1725 feet (526 m), dry hole, abandoned

TABLE 7. SUMMARY OF TEST HOLE DATA, HULLETT TOWNSHIP.

Test Hole Number: HU-TH-8
Location: Lot 28, Conc. 10
Elevation: Approximately 966 feet (294 m) a.s.l.
Source: From files of Petroleum Resources Section, M.N.R.

Depth feet (metres)	Description
0-83 (0-25)	drift
83-112 (25-34)	Dundee Formation
112-675 (34-206)	Detroit River Group
	test hole continued to 1803 feet (550 m), dry hole, abandoned

Test Hole Number: HU-TH-9
Location: Lot 30, Conc. 5
Elevation: Approximately 914 feet (279 m) a.s.l.
Source: From files of Petroleum Resources Section, M.N.R.

Depth feet (metres)	Description
0-45 (0-14)	drift
45-109 (14-33)	Dundee Formation
109-502 (33-153)	Detroit River Group
502-677 (153-206)	Bois Blanc Formation
	test hole continued to 1768 feet (539 m), abandoned

Test Hole Number: HU-TH-10
Location: Lot 28, Conc. 5
Elevation: Approximately 945 feet (288 m) a.s.l.
Source: From files of Petroleum Resources Section, M.N.R.

Depth feet (metres)	Description
0-93 (0-28)	drift
93-198 (28-60)	Dundee Formation
198-725 (60-221)	Detroit River Group
	test hole continued to 1845 feet (562 m), abandoned

Test Hole Number: HU-TH-11
Location: Lot 26, Conc. 5
Elevation: Approximately 971 feet (296 m) a.s.l.
Source: From files of Petroleum Resources Section, M.N.R.

Depth feet (metres)	Description
0-96 (0-29)	drift
96-209 (14-33)	Dundee Formation
209-738 (64-225)	Detroit River Group
	test hole continued to 1850 feet (564 m), abandoned

Test Hole Number: HU-TH-12
Location: Lot 18, Conc. 5
Elevation: Approximately 945 feet (288 m) a.s.l.
Source: From files of Petroleum Resources Section, M.N.R.

Depth feet (metres)	Description
0-81 (0-25)	drift
81-132 (25-40)	Dundee Formation
	test hole continued to 132 feet (40 m)

TABLE 8. SUMMARY OF GEOPHYSICS DATA, HULLETT TOWNSHIP.

- NONE -

TABLE 9. AGGREGATE QUALITY TEST DATA, HULLETT TOWNSHIP*.

Pit No.	COARSE AGGREGATE						FINE AGGREGATE
	Petrographic Number Granular & 16 mm Crushed	Hot Mix & Concrete	Chert Content %	Magnesium Sulphate Soundness	Absorption	Los Angeles Abrasion	Magnesium Sulphate Soundness
Licenced Pit 2	131.7	129.5-170.0	5.15	8.7-14.1	1.91-2.17	24.7-27.3	10.7
Licenced Pit 4	-	123.9	2.3	2.8	1.87	27	6.8
Licenced Pit 7	-	115	2.1	2.7	1.36	24.1	3.5
Pit 21	-	128.7	5.5	3.4	1.17	24.8	7.3
Pit 26	-	130.7	4.2	13.7	1.81	25	10.6
Pit 28	-	116.6	2.9	3.3	1.14	22	7.2
Pit 35	-	109.6-139.9	2.1	13.3	1.76	28	-
Pit 38	101.8	148.9	-	4.9	2.5	-	13.3

*Deike, 1982

NOTE: The quality test data refers strictly to a specific sample. Due to the inherent variability of sand and gravel deposits care should be excercised in extrapolating such information to the rest of the deposit.

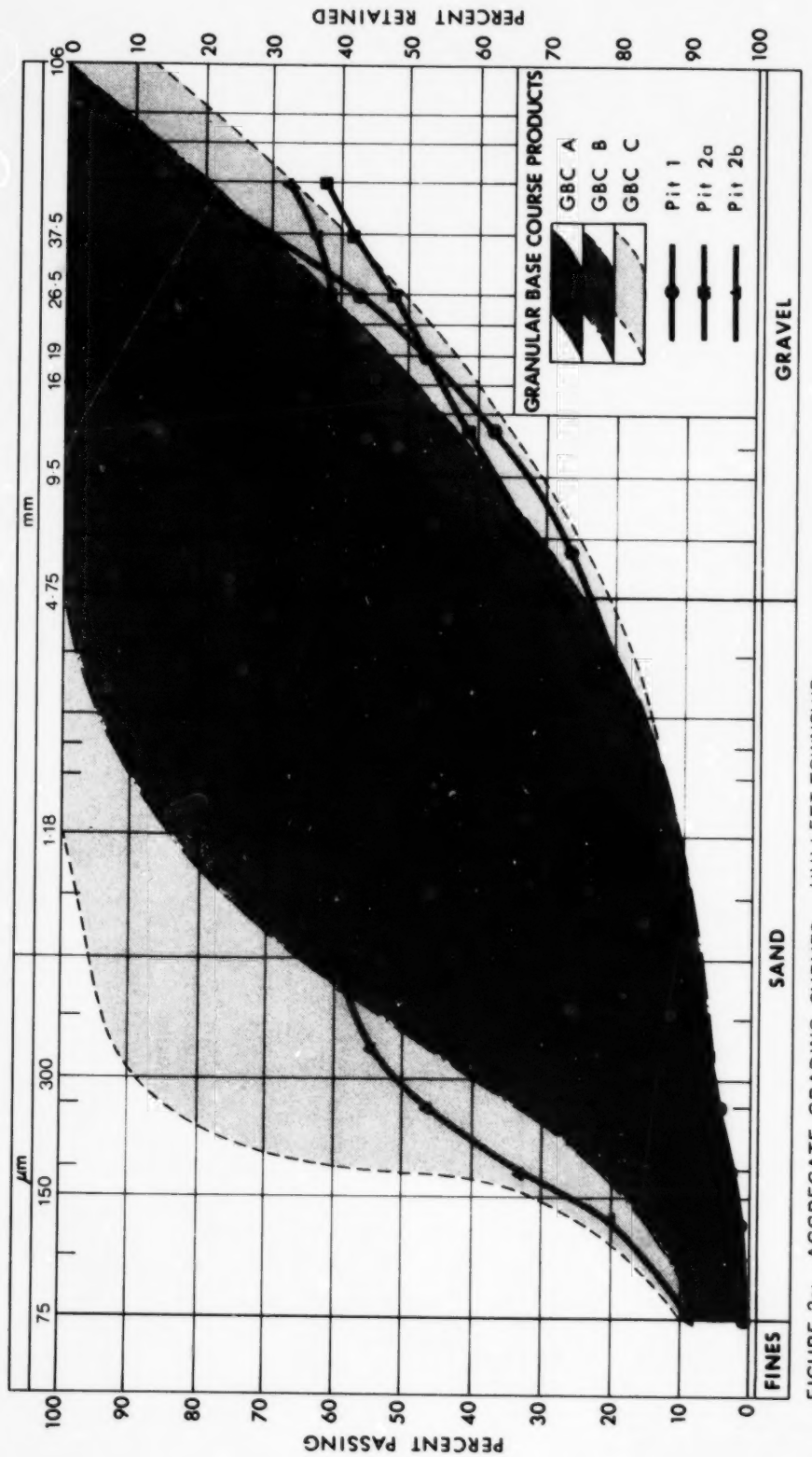


FIGURE 2a: AGGREGATE GRADING CURVES, HULLETT TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

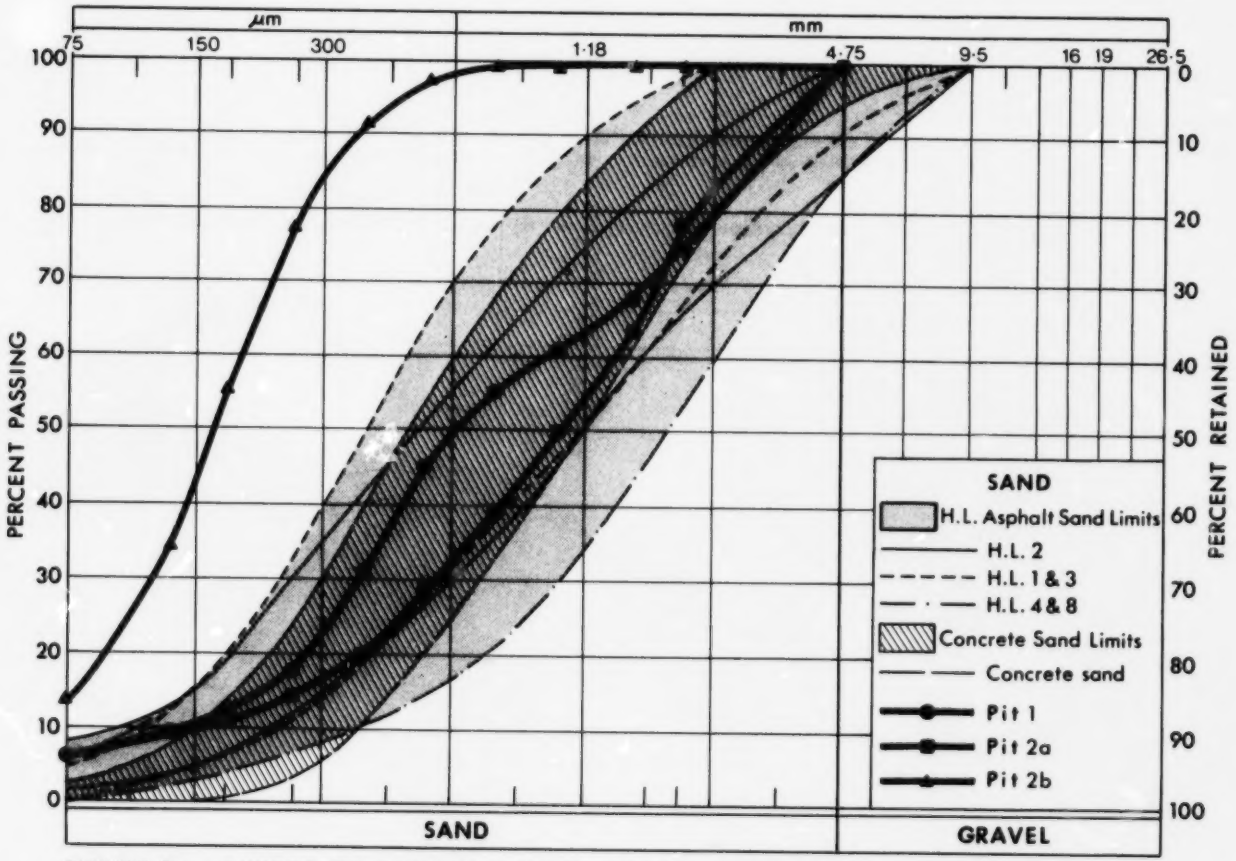


FIGURE 2b: AGGREGATE GRADING CURVES, HULLETT TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

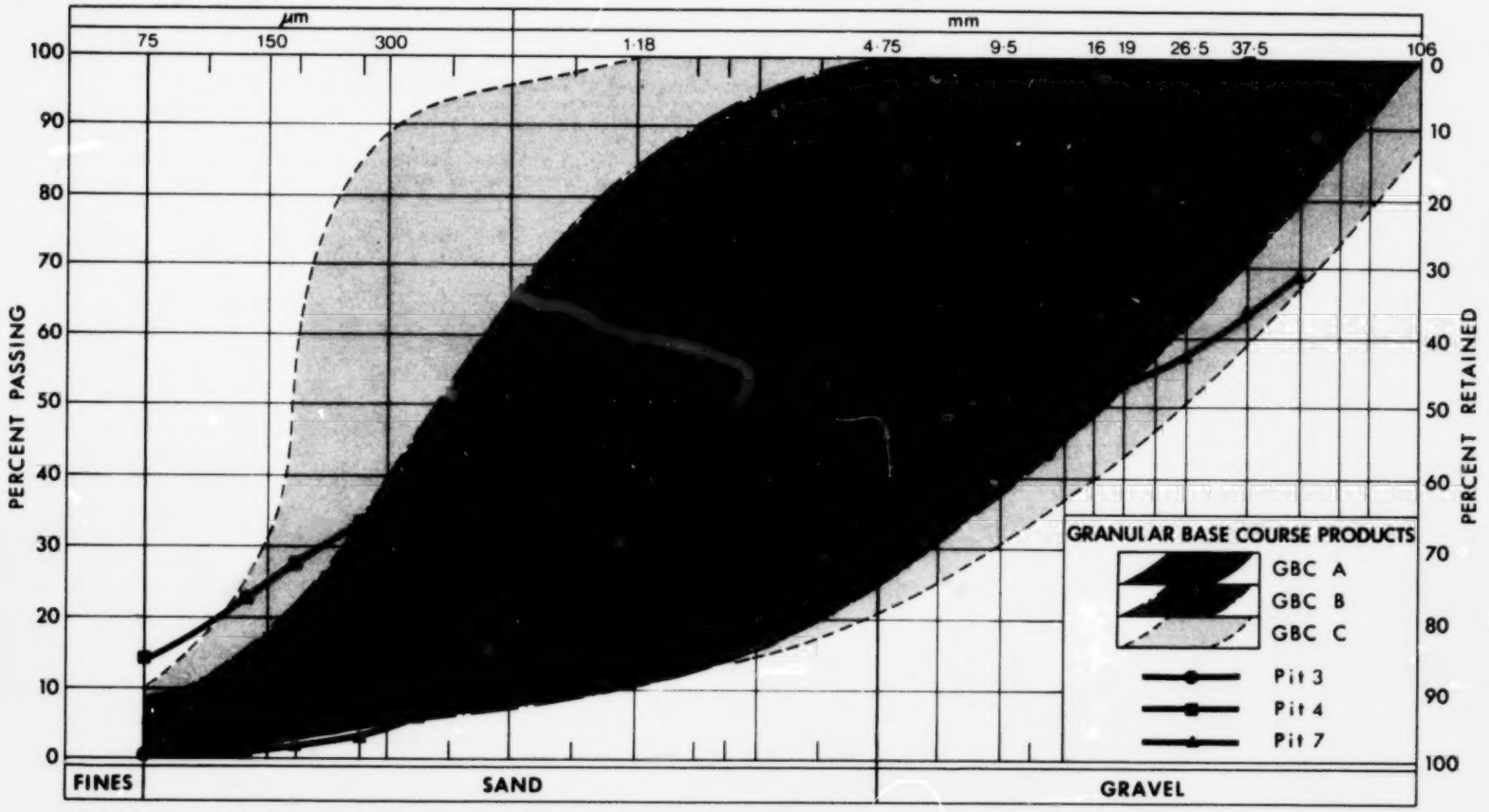


FIGURE 3a: AGGREGATE GRADING CURVES, HULLETT TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

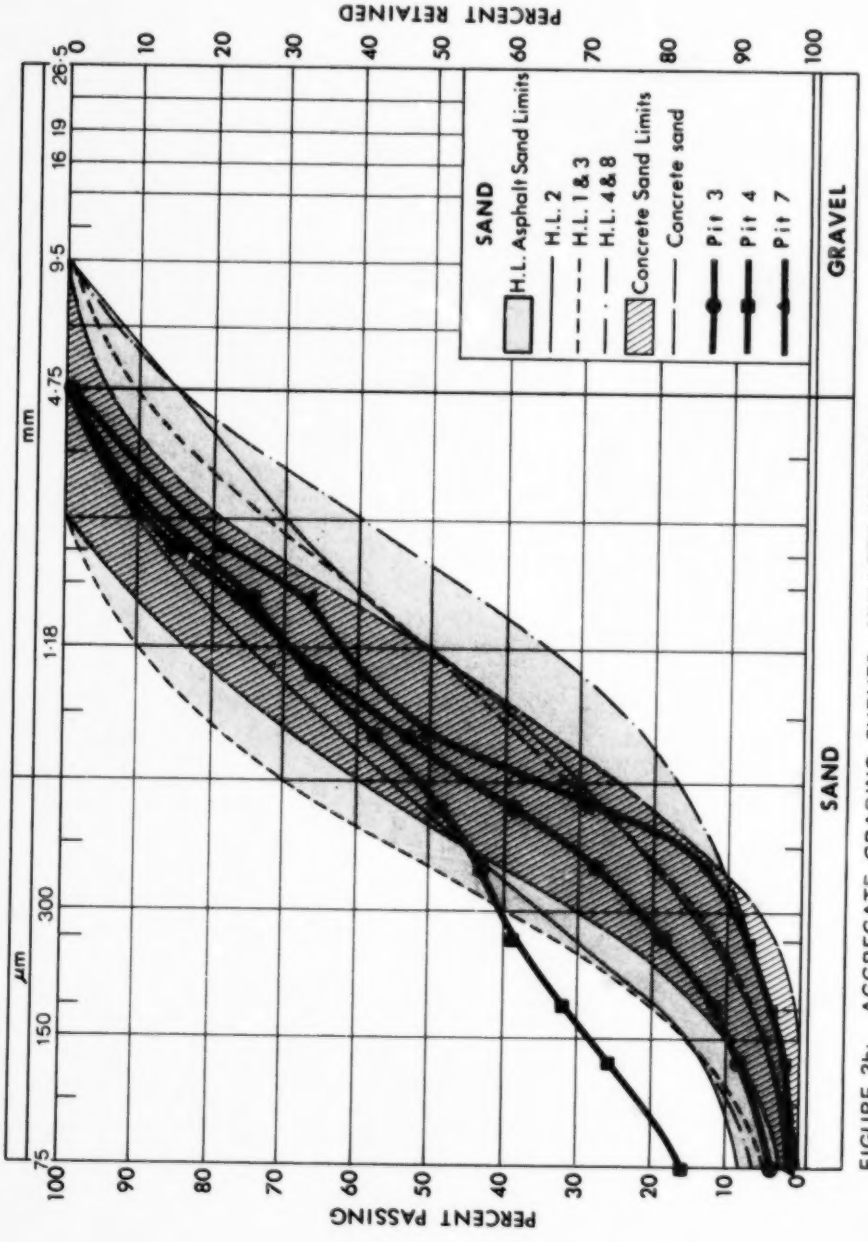


FIGURE 3b: AGGREGATE GRADING CURVES, HULLETT TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

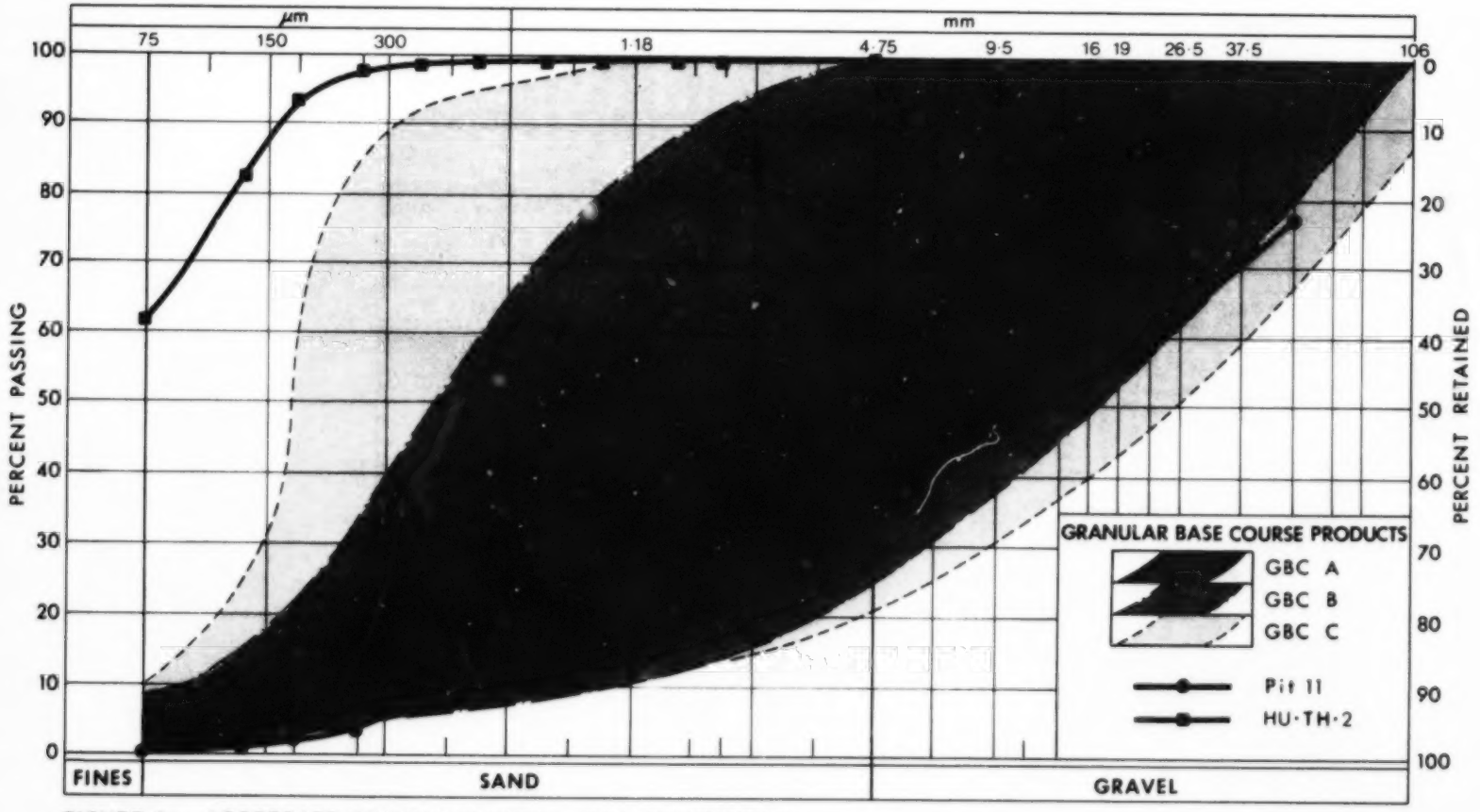


FIGURE 4a AGGREGATE GRADING CURVES, HULLETT TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

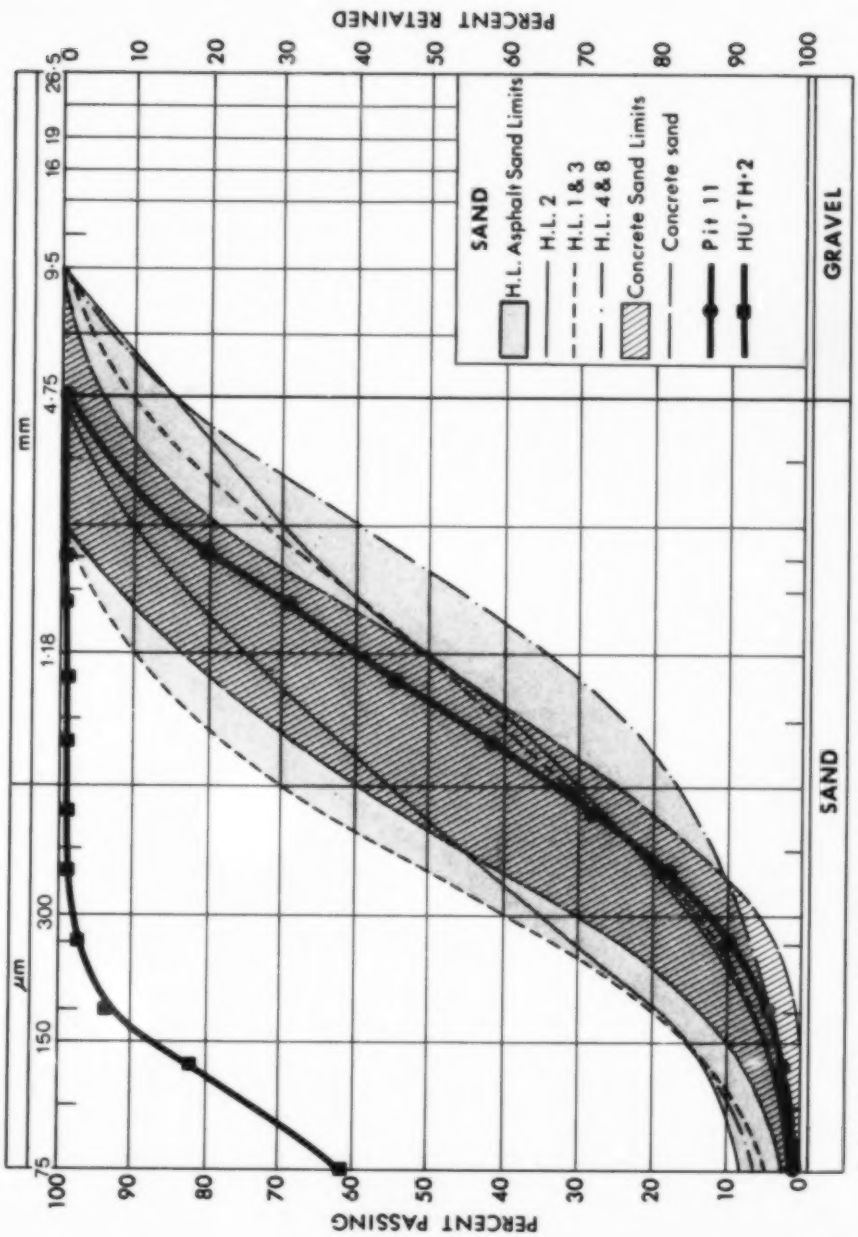


FIGURE 4b: AGGREGATE GRADING CURVES, HULLETT TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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Appendix B — Glossary

Abrasion resistance: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

Absorption capacity: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

Aggregate: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

Alkali-aggregate reaction: A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

Beneficiation: Beneficiation of aggregates is a process or combination of processes which improves the quality (physical properties) of a mineral aggregate and is not part of the normal processing for a particular use, such as routine crushing, screening, washing or classification. Heavy media separation, jigging, or application of special crushers (e.g. "cage mill") are usually considered processes of beneficiation.

Blending: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

Cambrian: The first period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago. The Cambrian precedes the Ordovician Period.

Clast: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

Crushable aggregate: Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

Deleterious lithology: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

Devonian: A period of the Paleozoic Era thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

Dolostone: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

Drift: A general term for all unconsolidated rock debris transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

Drumlin: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

Eolian: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

Fines: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

Glacial lobe: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

Gradation: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

Granular base course: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

Hot-laid (or asphaltic) aggregate: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2 and 8) used to bind the surface course to the underlying granular base course.

Lithology: The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

Magnesium sulphate soundness test: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually break down and give high losses in this test.

Meltwater channel: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

Ordovician: an early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

Paleozoic era: One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago, the Paleozoic Era (or Ancient Life Era) is subdivided into six geologic periods, of which only four (Cambrian, Ordovician, Silurian and Devonian) can be recognized in southern Ontario.

Petrographic examination: An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of the aggregate.

Pleistocene: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

Possible resource: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

Precambrian: The earliest geological period extending from the consolidation of the earth's crust to the beginning of the Cambrian.

Shale: A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

Silurian: An early period of the Palezoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

Soundness: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

Till: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

Wisconsinan: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

Appendix C — Geology of Sand and Gravel Deposits

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT): These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

Kames (K): Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuties. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

Eskers (E): Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC): This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW): Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Alluvium (AL): Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB): These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

Glaciolacustrine Deltas (LD): These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

Glaciolacustrine Plains (LP): The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

End Moraines (EM): These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD): Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consists of fine to coarse sand and are usually well sorted. The probabiltiy of locating crushable aggregate in windblown deposits is very low.

Appendix D — Geology of Bedrock Deposits

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

Bass Islands Formation (Upper Silurian)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11 to 18 m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunnville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate because of high soundness losses.

Bobcaygeon Formation (Middle Ordovician)

Composition: Compact, homogeneous, medium- to thin-bedded, fine-grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

Bois Blanc Formation (Lower-Middle Devonian)

Composition: Brownish grey, medium-crystalline, medium- to thin-bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High cherty content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

Dundee Formation (Middle Devonian)

Composition: Fine- to medium-crystalline, brownish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone. Used at St. Marys as raw material for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

Gull River Formation (Middle Ordovician)

Composition: Member A: thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield and Uhthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

Lockport and Amabel Formations (Middle Silurian)

Composition: Amabel Formation (Waterdown to the Bruce Peninsula): massive, fine-crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Waterdown to Niagara Falls): thin- to massive-bedded, fine- to medium-grained dolostone.

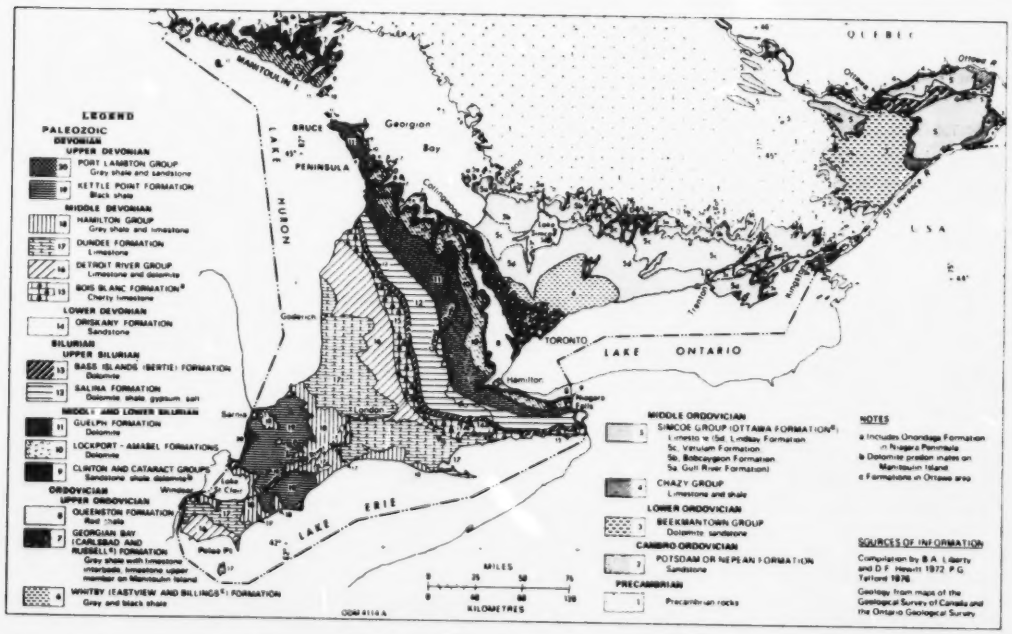

Figure 5. Bedrock Geology of Southern Ontario.

Thickness: Amabel Formation: maximum observed thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, concrete aggregate and building stone throughout their area of occurrence, and are a resource of provincial significance. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

Onondaga Formation (Middle Devonian)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliff Member: medium-bedded, fine- to medium-grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey-brown, fine-grained, very cherty limestone having estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey-brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High cherty content makes much of the material unsuitable for concrete aggregate.

Ottawa Formation (Middle Ordovician)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137 to 145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of limestone for cement production and agricultural uses.

Oxford Formation (Lower Ordovician)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES

Detroit River Group (Middle Devonian)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change) Composition: Near Beachville, the group consists of medium- to microcrystalline, medium-bedded, high-purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important source of high-purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces much of Ontario's lime and cement. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for crushed stone.

Grenville Marble (Precambrian)

Composition: Recrystallized fine- to coarse-grained white limestone and dolostone, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazzo chips, poultry grit, decorative stone, and building stone.

Guelph Formation (Middle Silurian)

Composition: Aphanitic to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. Thickness: 100 to 170 feet (30 to 52 m). Uses: The main use is for dolomitic lime in the construction industry. The formation is quarried near Hamilton and Guelph.

Lindsay Formation (Upper Ordovician)

Composition: fine-crystalline, rubbly, nodular-weathering limestone. Collingwood Member: organic-rich interbedded calcareous shales and limestones. Uses: Quarried at Picton, Ogden Point and Bowmanville for cement. The formation is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

Verulam Formation (Middle Ordovician)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200 to 300 feet (61 to 91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for use in cement manufacture. The formation is unsuitable for crushed stone because of clay impurities, many clayey interbeds, and low abrasion resistance, high soundness losses and poor freeze and thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

Georgian Bay Formation (Upper Ordovician)

(Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas) Composition: Soft, fissile, blue-grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Several producers in the vicinity of Metro Toronto produce brick and structural tile. Lightweight aggregate has been produced at Streetsville by heat expansion of the shale.

Hamilton Group (Middle Devonian)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The group has six formations, but only the Arkona Formation is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). The Arkona Formation has a thickness of 14 to 121 feet (4 to 37 m). Uses: The

Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile.

Queenston Formation (Upper Ordovician)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are several large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa. All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

Nepean (Potsdam) Formation (Cambro-Ordovician)

Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

Salina Formation (Upper Silurian)

Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum. The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amherstburg, Windsor, and Sarnia.

Blue Mountain Formation (Upper Ordovician)

(Formerly known as the Whitby Formation) Composition: Blue-grey, predominantly non-calcareous shale. Uses: Quarried at Bowmanville for use in cement production.

Appendix E — Aggregate Quality Test Specifications

Four types of aggregate quality tests are often performed by the Ontario Ministry of Transportation and Communications on sampled material. A description of each test is found in Appendix B while the specification limits for each test are included in this Appendix in Table E1. Although a specific sample meets or does not meet the specification limits for a certain product, it may or may not be acceptable for that use based on field performance. Additional quality tests other than the four major tests listed in this Appendix can be used to determine the suitability of an aggregate. The tests are performed by the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications.

TABLE E-1. SELECTED QUALITY REQUIREMENTS FOR MAJOR AGGREGATE PRODUCTS.

	TYPE OF TEST				
	COARSE AGGREGATE				FINE AGGREGATE
TYPE OF MATERIAL	Petrographic Number Maximum	Magnesium Sulphate Soundness - Max. % Loss	Absorption Maximum %	Los Angeles Abrasion Maximum % Loss	Magnesium Sulphate Soundness Maximum % Loss
Granular Base A	200	-	-	60	-
16 mm Crushed Type 'A'	160	-	-	35	-
16 mm Crushed Type 'B'	200	-	-	60	-
Granular Subbase B	250	-	-	-	-
Granular Subbase C	250	-	-	-	-
Granular Subbase D	-	-	-	-	-
Hot Mix - H. L. 1	100	5	1.0	15	16
Hot Mix - H. L. 2	-	-	-	-	20
Hot Mix - H. L. 3	135	12	1.75	35	16
Hot Mix - H. L. 4	160	12	2.0	35	20
Hot Mix - H. L. 8	160	15	2.0	35	20
Structural Concrete and Concrete Base	140	12	2.0	35	16
Pavement Concrete and Exposed Structure Deck	125	12	2.0	35	16

(M.T.C. Forms 1002, 1003 and 1010)

LEGEND

(Continued from right margin)

TEXTURE SYMBOL

The Texture Symbol provides quantitative assessment of the grain size distribution at a sampled location. The relative amounts of gravel, sand, silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The above example shows a hypothetical sample consisting of 45% gravel, 35% sand and 20% silt and clay.

DEPOSIT SYMBOL

Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel Content is expressed as a percentage of gravel-sized material (i.e. material retained on the 4.75 mm sieve). Thickness Class is based on potential aggregate tonnage per acre. Geological Type refers to geologic origin. Quality Indicator describes objectionable grain size and lithology.

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.

Thickness Class

Class	Average Thickness in Feet (Metres)	Tons per Acre	Tonnes per Hectare
1	greater than 20 (>6)	greater than 50,000	greater than 112 000
2	10 - 20 (3 - 6)	25,000 - 50,000	56 000 - 112 000
3	5 - 10 (1.5 - 3)	12,500 - 25,000	28 000 - 56 000
4	less than 5 (<1.5)	less than 12,500	less than 28 000

Geological Type

AL	Older Alluvium	**K**	Kame
E	Esker	**LB**	Lacustrine Beach
EM	End Moraine	**LD**	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	**LP**	Lacustrine Plain
		OW	Outwash
ICT	Ice-Contact Terrace	**WD**	Windblown Forms

(see Appendix C for descriptions of Geological Types)

Quality Indicator

	If blank, no known limitations present.
C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Oversize particles or fragments present in objectionable quantities.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.
Test hole data from Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Northern Development and Mines.
Selected water well data from the Ontario Ministry of the Environment.
Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.
Geology by: A.J. Cooper, 1976 a; A.J. Cooper and W.D. Fitzgerald, 1977; A.J. Cooper, W.D. Fitzgerald and J. Clue, 1977; and W.R. Cowan, in prep.
Additional Fieldwork by: Staff of the Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Northern Development and Mines.

Compilation and Drafting by: Staff of the Aggregate Assessment Office, Ontario Geological Survey, Ministry of Northern Development and Mines.
This map is to accompany O.G.S. Aggregate Resources Inventory Paper 108.

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Issued 1986.

Information quoted for an individual test hole or pit refers to a specific sample or face. Care should be exercised in extrapolating such information to other parts of the deposit.

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Ontario

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

HULLETT TOWNSHIP

HURON COUNTY

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale 1: 50 000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference: 40 P/11, 40 P/12
40 P/13, 40 P/14

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Location Map Scale: 1:1,800,000

LEGEND

(Some map units and symbols may not apply to this map.)

MAP UNITS

- Gravel deposit.
- Sand deposit.
- Gravel overlain by other surficial material.
- Sand overlain by other surficial material.
- Other surficial deposits or exposed bedrock.

SYMBOLS

- Buried geological and aggregate thickness boundary.
- Geological and aggregate thickness boundary of sand and gravel deposits.
- Municipal boundary.
- 2 — Licenced property boundary; Property number: see Table 2.
- ● 3 — Unlicenced sand or gravel pit*; Property number: see Table 2. *Abandoned pit or wayside pit operating on demand under authority of a permit.
- HU-TH-2 — Test hole location; identification number; see Table 7.
- O 6 24G — Selected water well location. Layers of materials are described by: reported thickness of material (in feet); reported type of material (number only - overburden, G - gravel, S - sand, C - clay, T - till, B - boulders, Bk - bedrock, Hpan-hardpan, Stn-stones).
- G 1 IC C-O — Deposit symbol; see below.
- Texture symbol; see below; see Figures 2 to 4.
- HU-GT-2 — Geophysical traverse line; Identification number: see Table 8.

(continued at left margin)

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ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

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HURON COUNTY

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale 1: 50 000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference: 40 P/11, 40 P/12
40 P/13, 40 P/14

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Location Map Scale: 1:1,800,000

LEGEND

(Some map units and symbols may not apply to this map.)

MAP UNITS

- 1 — Selected sand and gravel resource area, primary significance; deposit number; see Table 3.
- Selected sand and gravel resource area, secondary significance.
- Selected sand and gravel resource area, tertiary significance.

SYMBOLS

- Buried geological and aggregate thickness boundary.
- Geological and aggregate thickness boundary of sand and gravel deposits.
- Municipal boundary
- 2 — Licenced property boundary; Property number: see Table 2.
- ● 3 — Unlicenced sand or gravel pit*; Property number: see Table 2. *Abandoned pit or wayside pit operating on demand under authority of a permit.

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Selected water well data from the Ontario Ministry of the Environment.
Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.
Geology by: A.J. Cooper, 1978; B.V. Sanford and A.J. Baer 1981; T.T. Uyeno, P.G. Telford and B.V. Sanford, 1982; A.J. Cooper and L.P. Nicks, 1981.

Compilation and Drafting by: Staff of the Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Northern Development and Mines.
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AGGREGATE RESOURCES INVENTORY

HULLETT TOWNSHIP

HURON COUNTY

MAP 3
BEDROCK RESOURCES

Scale 1: 50 000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference: 40 P/11, 40 P/12
40 P/13, 40 P/14

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Location Map Scale: 1:1,800,000

LEGEND

(Some units and symbols may not apply to this map.)

BEDROCK UNITS

PALEOZOIC

DEVONIAN

MIDDLE DEVONIAN

DUNDEE FORMATION

Limestone

LOWER–MIDDLE DEVONIAN

DETROIT RIVER GROUP

LUCAS FORMATION

Dolostone , Limestone

DRIFT THICKNESS

- Bedrock outcrop (see Table 4); areas of exposed bedrock partially covered by a thin veneer of drift. Drift thickness is generally less than 3 feet (1 m).
- Bedrock covered by drift (see Table 4); drift thickness is generally 3 to 25 feet (1 to 8 m). Bedrock outcrops may occur.
- Bedrock covered by drift (see Table 4); drift thickness is generally 25 to 50 feet (8 to 15 m). Isolated bedrock outcrops may occur.
- Bedrock covered by drift; drift thickness is generally greater than 50 feet (15 m).

SYMBOLS

- 1 — Selected bedrock resource area; deposit number; see Table 6.
- Geological formation boundary.
- Geological formation member boundary.
- Formation thickness boundary (see text).
- 25 — Drift thickness contour. (3-foot, 25-foot and 50-foot contours are shown).
- Municipal boundary.
- Q2 — Licenced quarry boundary; Property number: see Table 5.
- ● Q3 — Unlicenced quarry*; Property number: see Table 5. *Abandoned quarry or wayside quarry operating on demand under authority of a permit.
- x — Isolated bedrock outcrop.
- O 24 — Selected water well location; reported depth to bedrock (in feet).
- HU-TH-6 — Testhole; identification number: see Table 7.

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